Session: ALE+AF-MoA16 Characterization of Al_2O_3 and HfO_2 Grown on Metal Surfaces with Thermal and Plasma Enhanced Atomic Layer Deposition **Abstract # 174**

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Abstract:

Atomic layer deposition (ALD) is potentially a very suitable deposition technology to grow ultra thin films with excellent thickness control, good conformity on high aspect ratio structures, and less defects. Al_2O_3 and HfO_2 are well-established high-k materials to replace SiO_2 in transistor and capacitor applications. To grow high quality ALD films with low leakage current, high breakdown electric field and dielectric constant, it is important to understand the impact of both plasma enhanced ALD (PEALD) with O_2-plasma and thermal ALD with H_2O on the interface between ALD film and substrate surface, and also the impact of the interface on the quality of ALD films.

We present the electrical and chemical characterizations of Al_2O_3 and HfO_2 films directly grown on Au, Ti and TiN surfaces. Metal Insulator Metal (MIM) capacitors with 10nm of Al_2O_3 or 10nm of HfO_2 as a dielectric layer were realized. Our results show that (1) the Al_2O_3 film grown by TMA metallic precursor and O_2-plasma has the highest breakdown electric field of 6.74 MV/cm, and the lowest leakage current of 8.6e-8 A/cm^2 at 2 MV/cm, which indicate that this 10nm of Al_2O_3 layer is high quality dielectric film with low pin-hole density and defects; (2) the HfO_2 film grown by TEMAH metallic precursor and H_2O has the lowest breakdown electric field of 3.95 MV/cm, and the highest leakage current of 7.6e-7 A/cm^2 at 2 MV/cm, which indicate that this 10nm of HfO_2 film has more pin-holes and defects; (3) the Al_2O_3 film grown by TMA and H_2O, and the HfO_2 film grown by TEMAH and O_2-plasma have the breakdown electric fields of 6.56 and 4.28 MV/cm, and the leakage currents of 2.40e-7 and 2.33e-7 A/cm^2 at 2 MV/cm, respectively; (4) both the Al_2O_3 and HfO_2 films grown by the PEALD with O_2-plasma show better qualities than that grown by the thermal ALD with H_2O; (5) the Al_2O_3 and HfO_2 with O_2-plasma processes do not show plasma-induced damage based on the tests of Van der Pauw (VdP) samples made from InGaAs-InAlAs layer structure with channels buried ~ 30 nm from the surface.

To further investigate, understand and optimize the ALD processes, Auger energy spectroscopy (AES) and high-resolution scanning Auger microscope (SAM) are used to analyze the chemical compositions and distributions in the interface between the ALD films (Al_2O_3 and HfO_2 grown with O_2-plasma and H_2O) and the metal surfaces (Au, Ti and TiN) without exposing the ALD films to air.